Estimated Duration of the Reducing Environment at the Saltstone Facility

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SAVANNAH RIVER NATIONAL LABORATORY

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Question, Background, & Our Approach

- Question: How long will the Saltstone facility remain reducing, thereby immobilizing several key radionuclides, including ^{99}Tc?

- Background: Slag (waste product from smelting) is purposely added to Saltstone to make it a reducing formulation.

  $$Tc^{VII}O_4^- + 3e- + 4H^+ \rightarrow Tc^{IV}O_2\text{-}2H_2O$$

  - Soil Kd $Tc^{VII}O_4^-$ = 0 mL/g
  - Soil Kd Tc^{IV} = 4000 mL/g

- Approach: Reactive transport modeling based on a conceptual model from lysimeter field study and input values from laboratory measurements.

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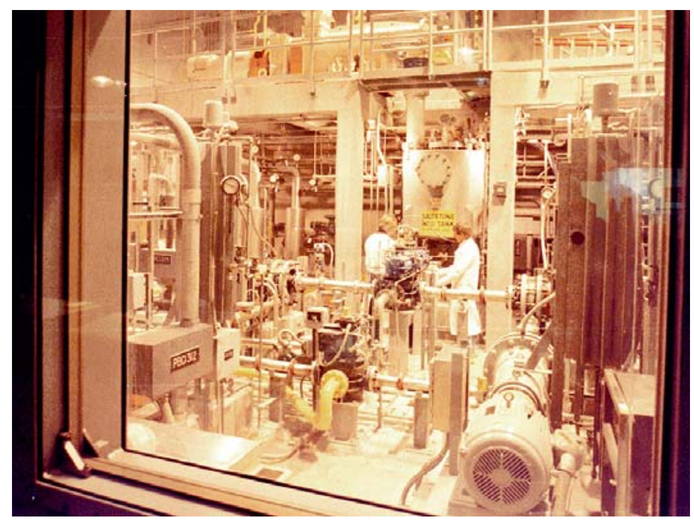
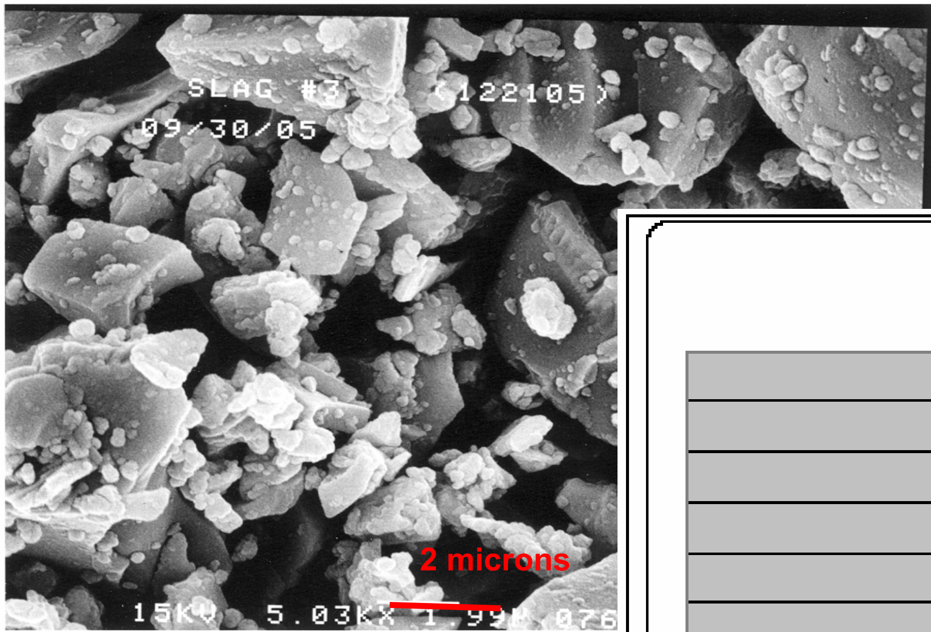
Saltstone Facility

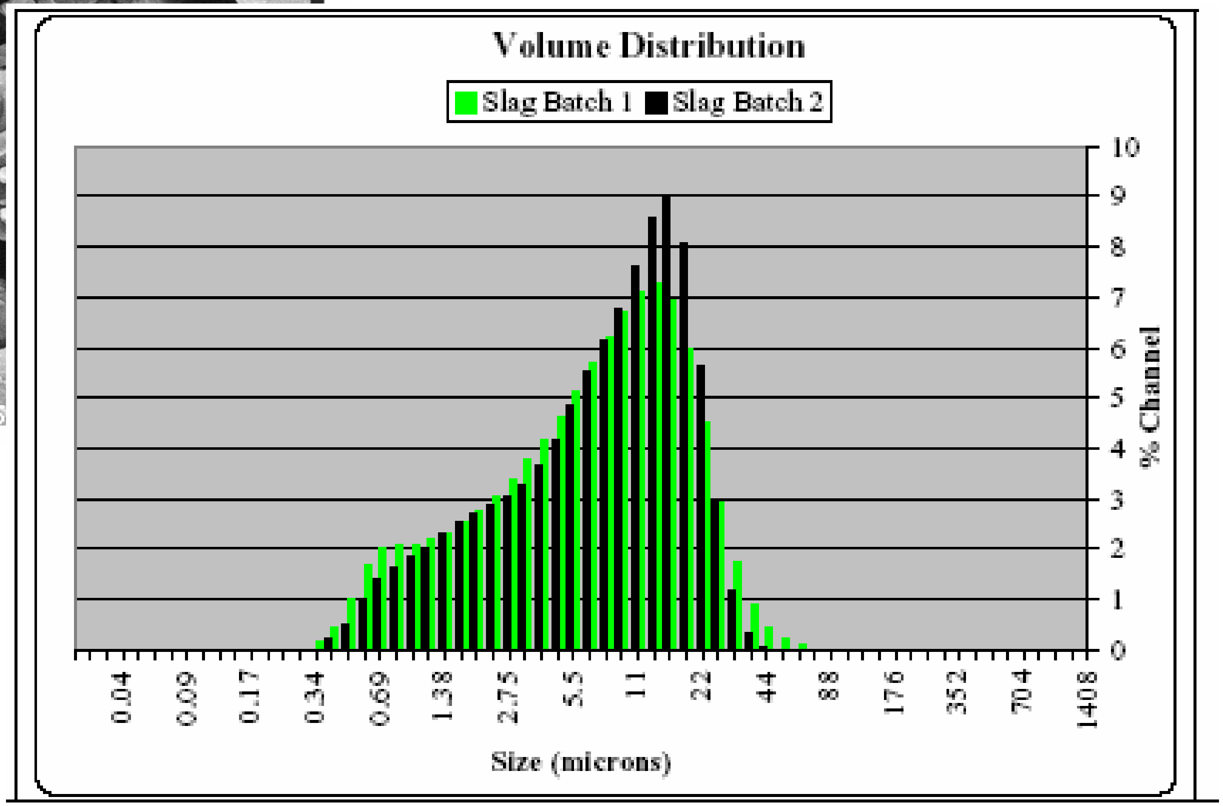
- Facility been operating intermittently since 1990.
- 2 vaults: 12 cells + 6 cells, cell = 100 x 100 x 25 ft.
- Vaults are partially filled.
- Saltstone: ~47% LLW liquid + ~3% cement + ~25% fly ash + ~25% slag
- 99% radioactivity → glass HLW; 90% volume → Saltstone

- 2011 start Salt Waste Processing Facility



Blast Furnace Slag

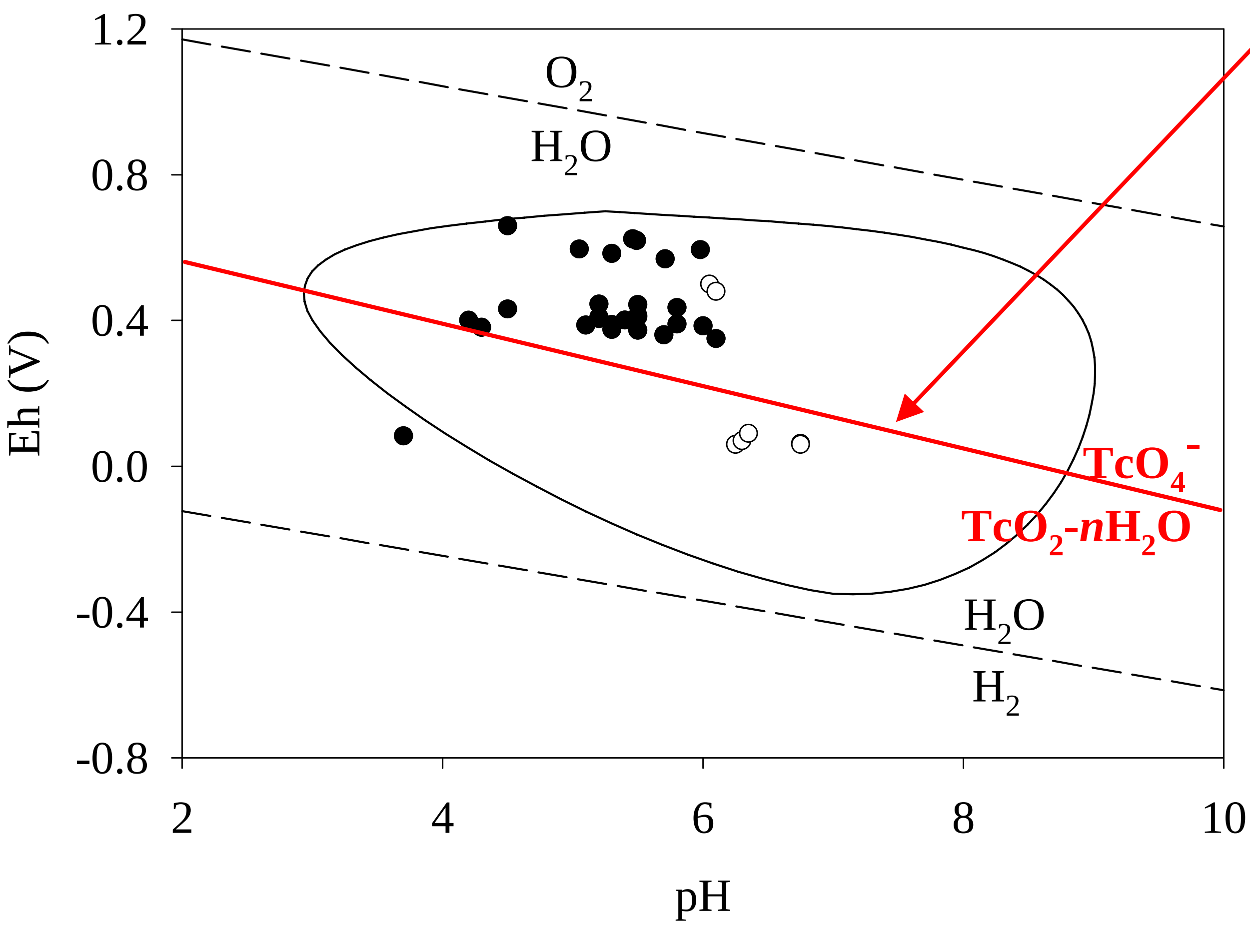




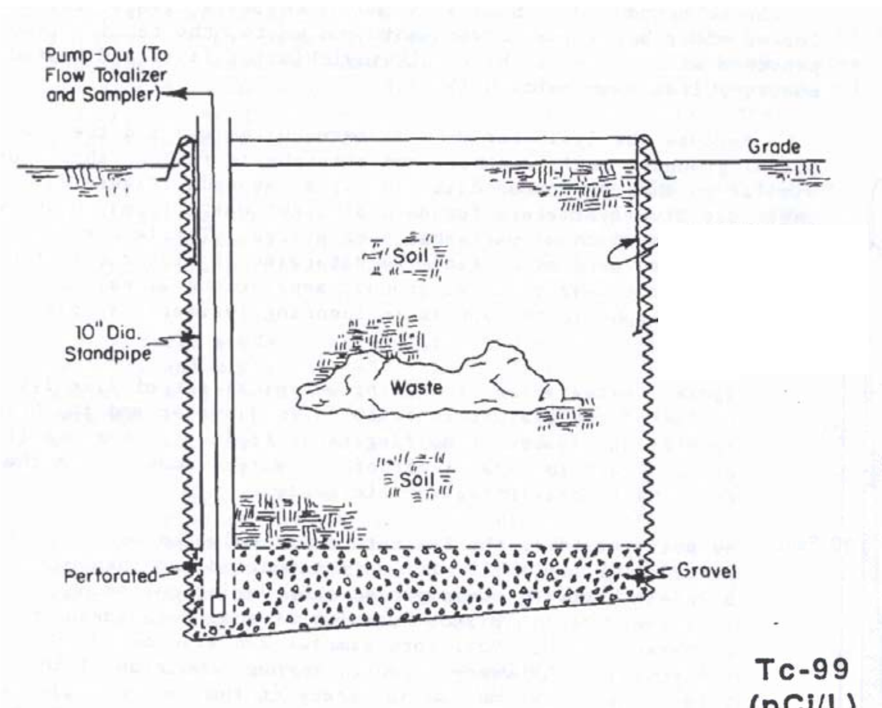
Harbour et al. 2006

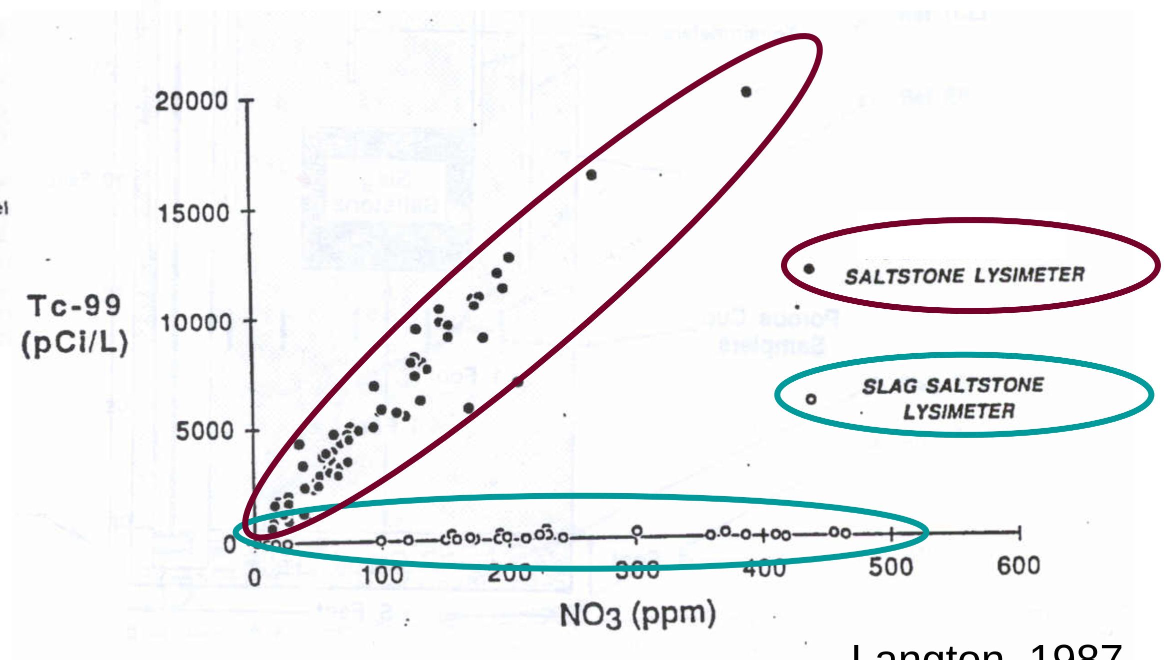
Tc(VII) vs. Tc(IV) in the SRS Subsurface

$TcO_4^- + 3e^- + 4H^+ \rightarrow TcO_2 \cdot 2H_2O$



2.5 Year Field-Lysimeter Study: Saltstone Slag





Langton, 1987

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Chemistry in Reactive Transport Model

$O + e^- \leftrightarrow R$

O = oxidizing agent

R = reducing agent

e- = electron

$O_{2(aq)} + R_{slag(Saltstone)} \rightarrow RO_{2(Saltstone)}$

$O_{2(aq)}$ = dissolved O_2 MEASURED

$R_{slag(Saltstone)}$ = Saltstone reduction capacity

MEASURED

$RO_{2(Saltstone)}$ = oxygenated Saltstone CALCULATED

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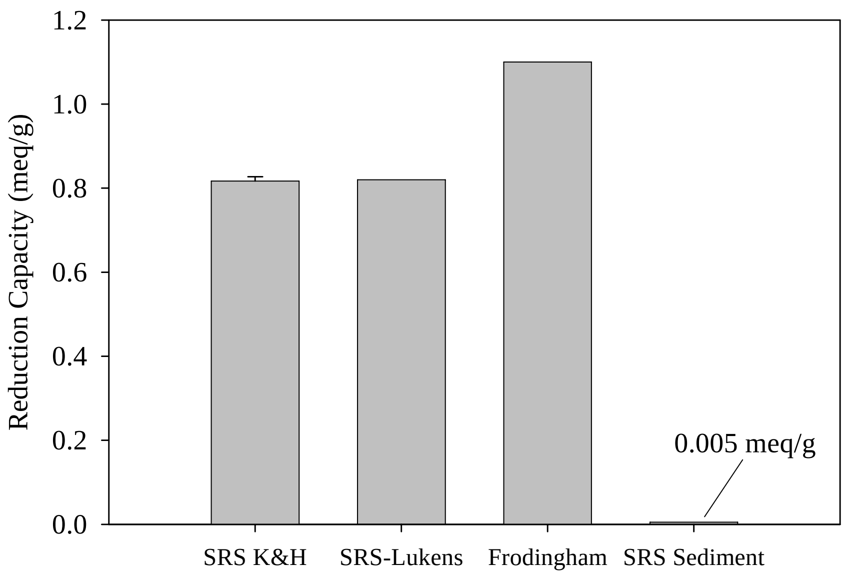
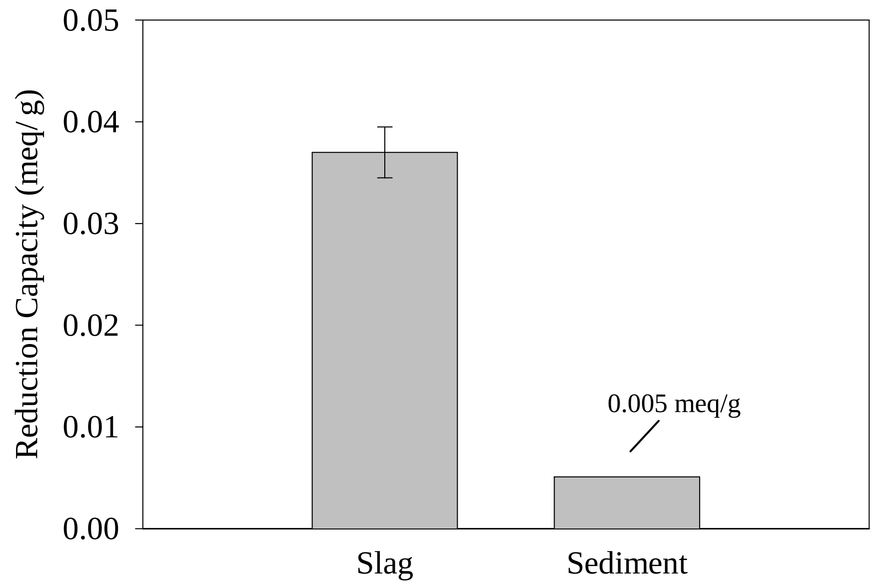
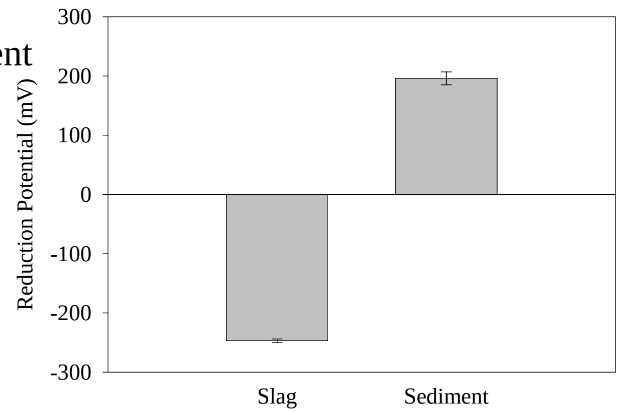
Reduction Capacity



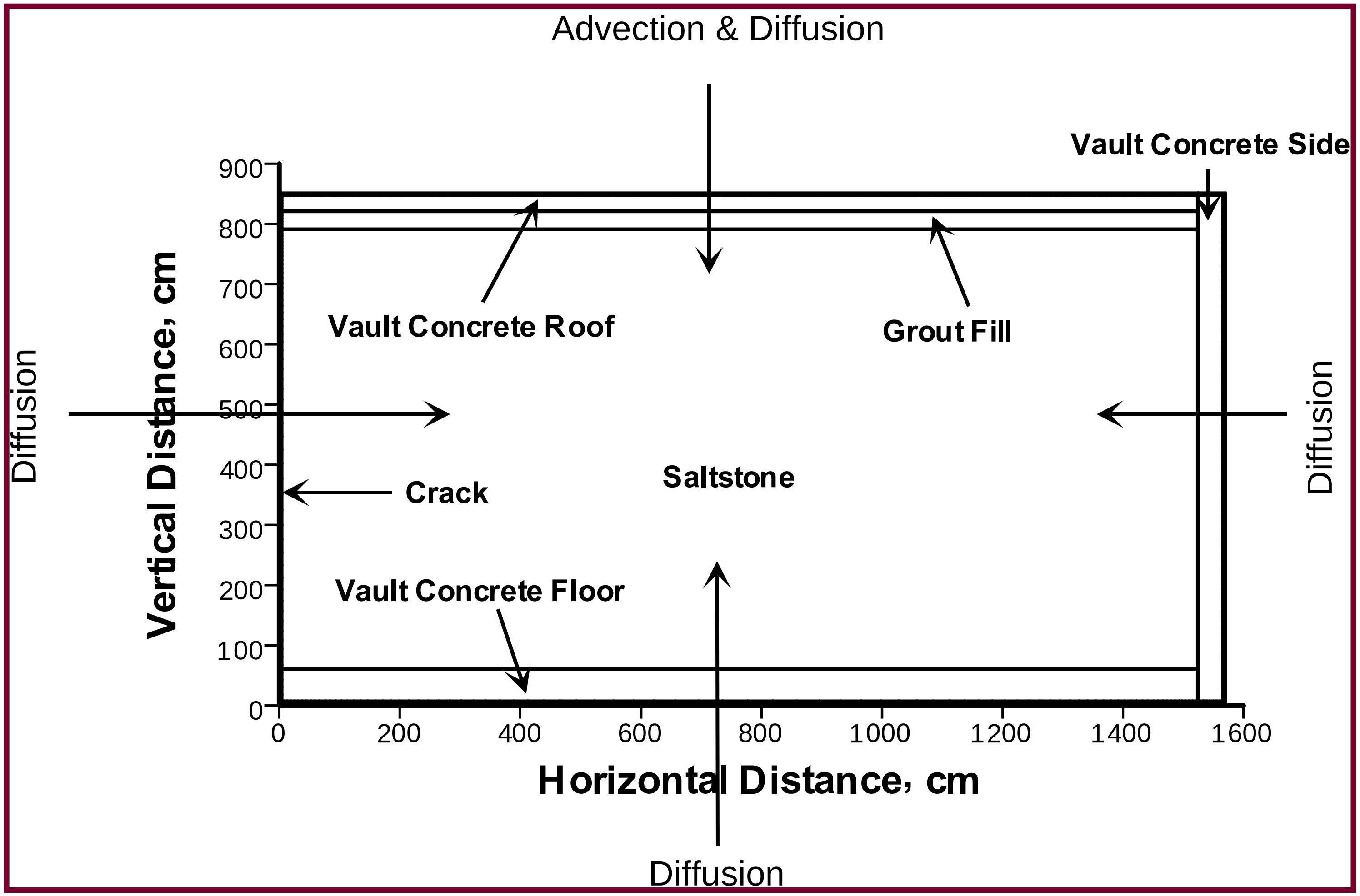
“Total Reduction Capacity”
Ce(VI) → Ce(III) in acidic environment
Angus & Glasser (1985)



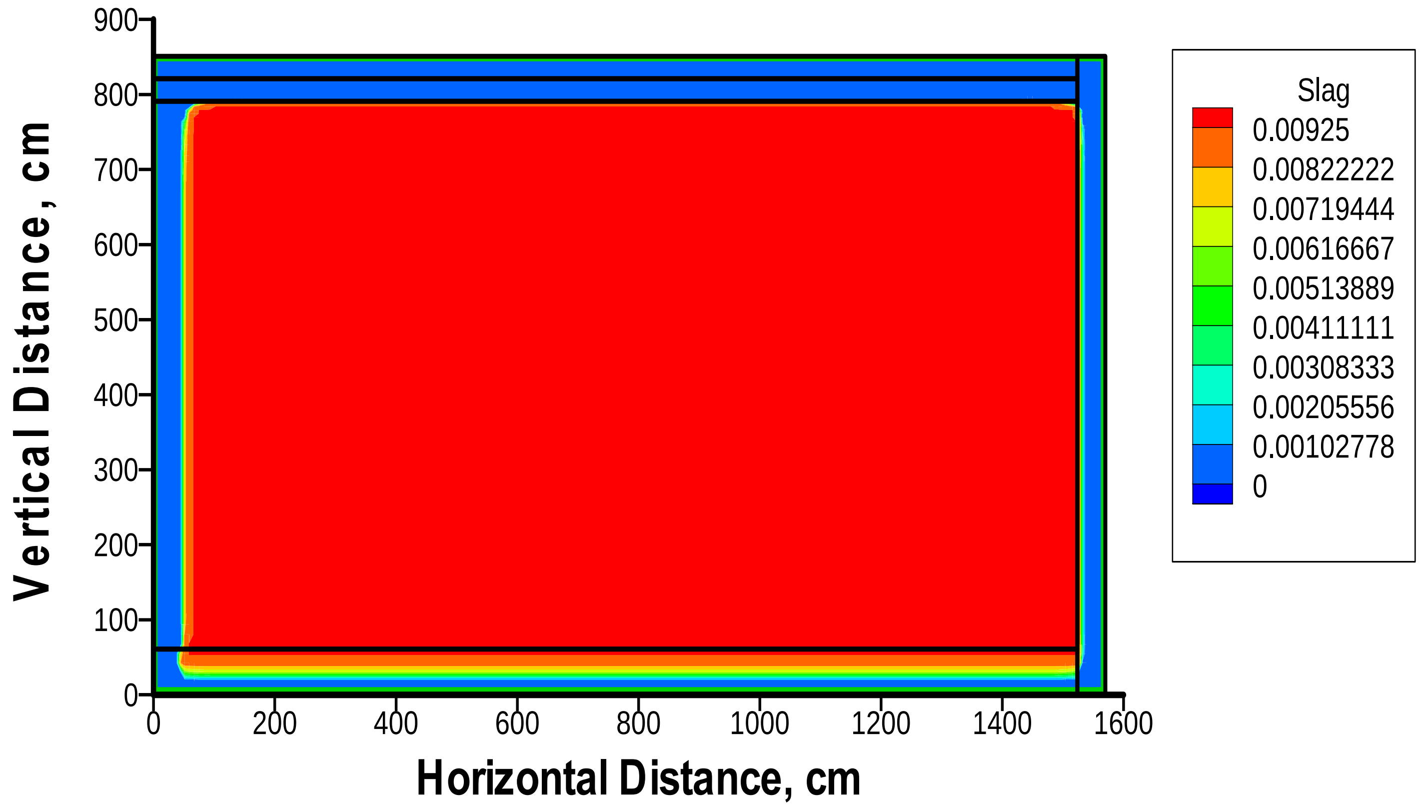
“Surface Reduction Capacity”
Cr(VI) → Cr(III) @ pH 7
Lee & Batchelor (2003)



Hydrology in Reactive Transport Model



Simulation Results at 250,000 Years



Red = Reduced Blue = Oxidized

(units: meq e-/g solid)

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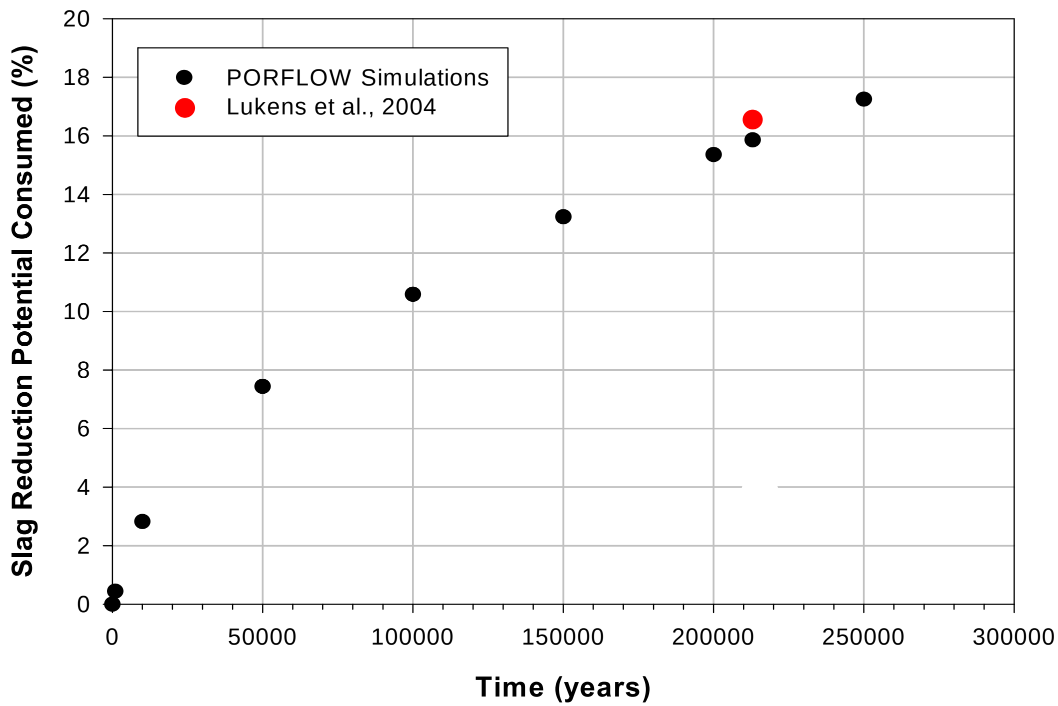
Consumption of Slag Reduction Potential by Oxygen in Infiltration Water



Governing equation for PORFLOW

$$\frac{\partial C_k}{\partial t} + \frac{\partial}{\partial x_i}(V_i C_k) = \frac{\partial}{\partial x_i}(D_{ij}\frac{\partial C_k}{\partial x_j}) + R_k$$

$$\frac{\partial C_{Sk}}{\partial t} = \frac{\partial}{\partial x_i}(D_{ij}\frac{\partial C_{Sk}}{\partial x_j}) + R_{Sk}$$

Governing equation for Lukens et al.

$$\boxed{\frac{I_d}{I_{\text{tot}}} = 1 - \exp\left[-\left(\frac{\mu_i}{\sin\phi} + \frac{\mu_f}{\sin\theta}\right)d\right]}$$

$$\boxed{d = \sqrt{\frac{8C_{O_2}tD_{m(O_2)}}{N_m C_{\text{red}}}}}$$

Conclusion

Obtaining similar results by two extremely different sets of calculations & assumptions provided additional assurance to the conclusion that the Saltstone Facility will maintain its reducing environment for >10,000 years (WSRC-RP-2003-00362, Rev. 2; WSRC-RP-2005-01674).